International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-11 Issue-6, May 2022

Load Based Carrier Aggregation Algorithm for LTE-Advanced

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Abstract*: Long Term Evolution (LTE) supports transmission bandwidth upto 20MHz. Nowadays the multimedia rich applications connects billions of users worldwide. These services demands more number of Resource Blocks (RBs) to satisfy the Quality of Service (QoS) requirements and that can increase the data traffic in multifold. This crunch has led the Mobile Network Operators (MNOs) to increase the transmission bandwidth in order to fulfil the QoS requirements of the different services. In Release10, Third Generation Partnership Project (3GPP) provides a provision for MNOs to use Carrier Aggregation (CA) scheme in LTE-Advanced to aggregate upto five Components Carriers (CCs) of existing LTE carriers at the eNB to increase the transmission bandwidth upto 100MHz. Further, this scheme allows a User Equipment (UE) to transmit and receive data packets simultaneously on multiple CCs based on UE capability to meet the service requirements. However, the CC selection and efficient RBs utilization plays a vital role to optimize the system performance. Hence, in this paper using QualNet 8.2 network simulator the Load Based Carrier Aggregation Algorithm (LBCAA) is proposed for LTE-Advanced to aggregate the CCs of the existing LTE carriers at the eNB based on cell load in order to increase the transmission bandwidth to handle the data traffic growth. The simulations results illustrated that the proposed LBCAA for LTE-Advanced outperforms in the achieved average unicast received throughput, average unicast end-to-end delay and jitter as compared to LTE.

Keywords: CA, CC, LBCAA, LTE-Advanced, QoE, QoS, RBs

I. INTRODUCTION

In cellular communications, LTE enables new innovations and brings multimedia rich applications such as mobile TV, high definition (HD)/full HD videos, high quality (HQ) video conference and online gaming services for mobile users with broadband QoE. Further, the technological development in mobile industry brings out smartphones, iPhones and laptops with affordable price. These smart devices support all kinds of multimedia services that lead to rapid growth in the number of mobile users worldwide. The multimedia rich applications demands more number of RBs to meet their greedy data rates constrain leads to increase in LTE network data traffic in multifold [1]. Thus, in higher data traffic scenarios in LTE a maximum 20MHz transmission bandwidth is not sufficient to provides an expected RBs for multimedia rich services [2]. Hence, the MNOs needs wider transmission bandwidth to allocate necessary RBs to fulfil data rates constraint of multimedia rich services [3].

In Release10, 3GPP specifies CA scheme for LTE-Advanced to increase the transmission bandwidth upto 100MHz. Further, this scheme allows network designer to aggregate existing LTE carriers such as 1.4, 3, 5, 10, 15 and 20MHz at the eNB to increase the transmission bandwidth based on data traffic growth. Each aggregated carrier is called Component Carrier (CC) and can support backward compatible operation to provide interoperability between the CA and non-CA deployments [4]-[8]. The CA scheme also allows LTE-Advanced UEs to transmit and receive data packets simultaneously on multiple CCs from a single eNB depending on its capabilities to increase the throughput with reduced latency in both uplink and downlink. In cellular communications, users are random in nature and requests for Voice over Internet Protocol (VoIP) and other types of data services anywhere anytime. This may vary the data traffic randomly and hence the MNOs needs scalable transmission bandwidth to handle the data traffic under different load conditions [9] [10].

To tackle this issue, in this paper the Load Based Carrier Aggregation Algorithm (LBCAA) is proposed for LTE-Advanced to increase the transmission bandwidth as the cell load surpasses its capacity. The proposed LBCAA is designed using QualNet 8.2 network simulator. Based on cell load, the proposed LBCAA aggregates upto five CCs of existing LTE carriers each with 20MHz at the eNB to increase the LTE-Advanced transmission bandwidth 40MHz, 60MHz, 80MHz and 100MHz to handle the different load conditions efficiently.

The rest of this paper is organized as follows. Section II outlines the related work in the literature. Section III and IV describes the overview and types of CA schemes. Section V illustrates the proposed Load Based Carrier Aggregation Algorithm (LBCAA) for LTE-Advanced. Simulation assumptions and models are illustrated in section VI. The simulations results are described in section VII and section VIII concludes the paper.

II. RELATED WORK

In LTE-Advanced, the CA scheme is a promising approach for MNOs to increase the transmission bandwidth in order to handle the exponential data traffic growth in both uplink and downlink. Several researchers and academia proposed several schemes to aggregate the available LTE spectrum to increase LTE-Advanced transmission bandwidth upto 100MHz.

Manuscript received on 28 April 2022.
Revised Manuscript received on 10 May 2022.
Manuscript published on 30 May 2022.
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In [3], CA scheme enables network operators to aggregate multiple LTE CCs, each with upto 20MHz wider to increase the transmission bandwidth upto 100MHz to enhance the data rates and QoS requirements of stationary and high mobility users in both uplink and downlink. In [4], release10 CA feature allows scalable expansion of effective bandwidth by aggregating the same or different band spectrum. This allows user for concurrent utilization of RBs that are from the same or different bands to enhance QoS and provides maximum flexibility for operators to utilize the available radio spectrum to increase network capacity. In [6], CA scheme considers the bandwidth, RB allocation, channel quality and load of CCs to satisfy QoS requirement of different services. In [11], Utility Balance CC Selection (UBCS) scheme improves utility of CA to enhance load balance factor, per user throughput as well as fairness among UEs. In [12], the CA scheme combines the multiple CCs to increase the transmission bandwidth to achieve higher throughput in cellular network. In [13], increase in the number of CCs aggregations increases transmission bandwidth that extensively increases the cell coverage area and RSRP of the network, and reduces the BLER. In LTE-A, the aggregation of intra or inter-band CCs enhance the user throughput significantly to satisfy the QoS requirements of different services [14]. In LTE-Advanced network, more efficient and optimum Radio Resource Management (RRM) algorithm assigns CCs, RBs and Modulation and Coding Scheme (MCS) to the user in accordance with their Channel State Information (CSI) and CA capabilities to satisfy their QoS requirements [15]. In [16], CA scheme enable network operator to utilize the available RBs more efficiently to enhance the network capacity and user QoE by reducing operating expenses and capital expenditures. In [17], CC packet scheduling algorithm increase the cell coverage as well as RBs allocation fairness between UEs. In [18], RB scheduling with carrier aggregation offers minimum guaranteed QoS for each user. In LTE-Advanced network [19], dynamic and optimal CC load balancing scheme doubles the average user throughput compared to Round Robin (RR) and Maximum Component Carrier to Interference (MCCI) load balancing schemes. The literature survey illustrates that the scalable expansion of effective bandwidth and efficient utilization of radio resources can enhance the network capacity and per user throughput. Hence, in this paper LBCAA is proposed for LTE-Advanced to increase the transmission bandwidth based on cell load and utilize the RBs of LTE and aggregated CCs more efficiently to satisfy the QoS requirements of the different services.

III. OVERVIEW OF CARRIER AGGREGATION

In Release 10, 3GPP specifies CA scheme for LTE-Advanced to increase the transmission bandwidth where multiple CCs can be aggregated and simultaneously used for data transmissions of particular UE based on its capability to satisfy the QoS requirements [20]. An idea of multi carrier usage is to handle the exponential data traffic growth and to support multimedia rich services with broadband QoE [21]. The CCs are configured based on cell capacity and QoS requirements [22]. The aggregation of continuous spectrum of 2CCs each with 10MHz can increase the LTE-Advanced transmission bandwidth 20MHz at the eNB and can support the peak data rates 150Mbps. Furthermore, the aggregation of 2CCs and 3CCs each with 20MHz can increase the LTE-Advanced transmission bandwidth 40MHz and 60MHz, and can support the peak data rates 300Mbps and 450Mbps respectively [23]. The aggregation of upto five CCs each with same or different bandwidth at the eNB can increase the transmission bandwidth upto 100MHz (Fig.1) and can support the peak data rates 1Gbps for low mobility user and 100Mbps for high mobility user.

In CA scheme, the CC is either a Primary Component Carrier (PCC) or a Secondary Component Carrier (SCC). In carrier aggregated LTE-Advanced network, the PCC carries data traffic and Radio Resource Control (RRC) signaling messages, whereas SCCs carries only data traffic. The UEs are associated with a PCC and multiple SCCs to transmit and receive the data packets simultaneously depending on UE capabilities, and downlink as well as uplink scheduler within a transmission interval to satisfy the QoS requirements [24].

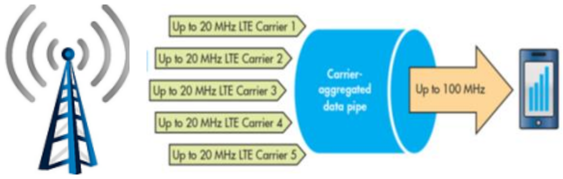

Fig. 1.Carrier Aggregation scheme in LTE-Advanced

IV. TYPES OF CARRIER AGGREGATION

In LTE-Advanced, the CA scheme aggregates multiple CCs from the same frequency (intra-frequency) band or different frequency (inter-frequency) band to increase the transmission bandwidth in both uplink and downlink. Each CC can be configured independently for both uplink and downlink. The increase in transmission bandwidth reduces the latency, enables new services and provides flexibility in frequency allocation to increase the cell capacity and per user throughput [8][20]. The intra-band contiguous, intra-band non-contiguous and inter-band non-contiguous CA schemes can be used in LTE-Advanced to increase the transmission bandwidth upto 100MHz. The numbers of Physical Resource Blocks (PRBs) available in the frequency domain with different transmission bandwidth are listed in Table I [25][26].

Table-I: Transmission bandwidth with PRBs

Bandwidth (MHz)	20	40	60	80	100
No. of PRBs	100	200	300	400	500

A. Intra-band contiguous and intra-band non-contiguous CA schemes

Intra-band contiguous CA scheme is used where multiple CCs belong to the same frequency band and adjacent to each other. This scheme can be expected in future LTE-Advanced network when 3.5GHz new spectrum band is allocated in various parts of the world [27]-[29]. Fig.2 shows the intra-band contiguous CA scheme.

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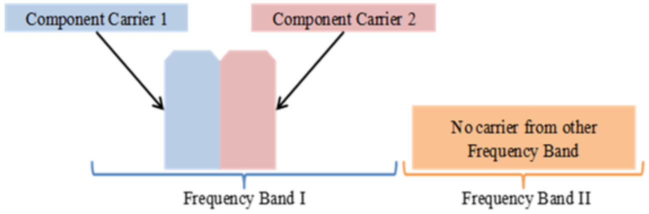

Fig. 2.Intra-band contiguous CA scheme

Fig.3 shows the intra-band non-contiguous CA scheme. This scheme is used where multiple CCs belong to the same frequency band, but allocated in non-contiguous manner. This scheme can be expected in LTE-Advanced network when the middle of the CCs are used by shared networks or loaded with other users [28] [29].

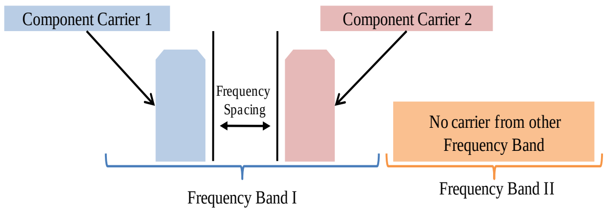

Fig. 3.Intra-band non-contiguous CA scheme

B. Inter-band non-contiguous CA scheme

Fig.4 shows the inter-band non-contiguous CA scheme. This scheme is used when multiple CCs belong to the different frequency bands and are allocated in a non-contiguous manner. This CA scheme can improves the mobility robustness by exploiting different radio propagation features of different frequency bands [4].

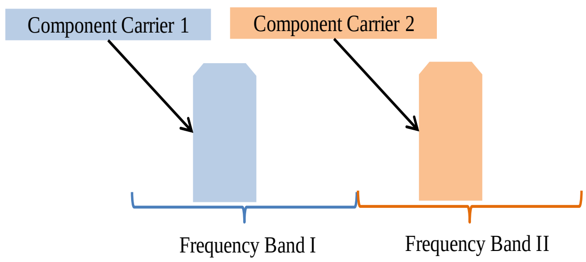

Fig. 4.Inter-band non-contiguous CA scheme

V. PROPOSED LOAD BASED CARRIER AGGREGATION ALGORITHM (LBCAA) FOR LTE-ADVANCED

An idea behind the proposed Load Based Carrier Aggregation Algorithm (LBCAA) is to aggregate upto five CCs of the existing LTE carriers at the eNB based on its capacity to increase the LTE-Advanced transmission bandwidth upto 100MHz to handle the data traffic growth and to satisfy the QoS requirements of the different services.

In LTE, when the data traffic surpasses its capacity, the QoE of in-progress services may deteriorates due to scarcity of RBs and network congestion. To cope up this problem, the LBCAA is proposed for LTE-Advanced network. This proposed algorithm aggregates upto five CCs of the existing LTE carriers at the eNB based on cell load to provide a sufficient number of RBs for data transmissions of in-progress services. Fig.5 shows the flowchart of proposed LBCAA for LTE-Advanced.

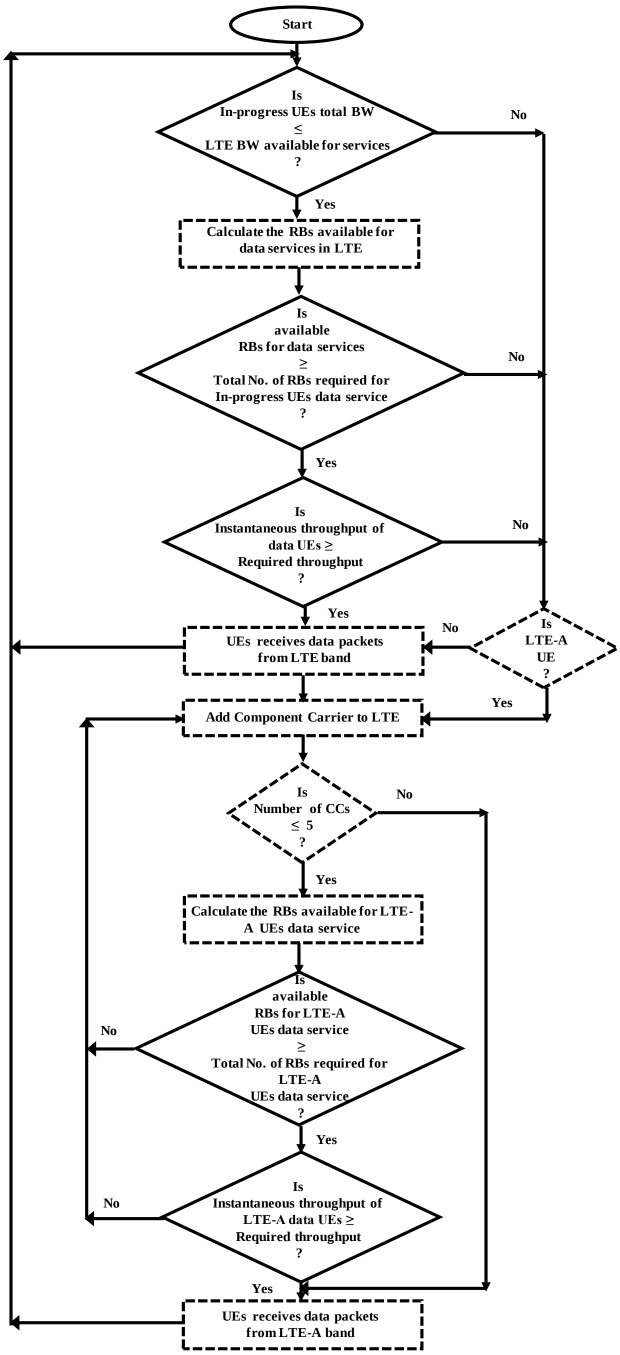

Fig. 5.Flowchart of proposed LBCAA for LTE-Advanced

The proposed LBCAA follows the standard LTE procedure during network entry. Then, it starts to estimate the total amount of bandwidth available at the eNB for services and the total amount of bandwidth necessary for in-progress services. If the sufficient amount of bandwidth is available at the eNB, then the number of RBs available to forward the data packets of in-progress services is calculated. As the allocatable available RBs are sufficient to forward the data packets of the service, then the instantaneous throughput is measured. If the instantaneous throughput is more than its necessary throughput, the UE can transmit and receive the data packets by using RBs of LTE spectrum.

Otherwise, the available CC of the existing LTE carrier is aggregated at the eNB to increase the average number of RBs available for data transmissions. If the allocatable available RBs of LTE and aggregated CC are sufficient to satisfy the QoS requirements of LTE-Advanced UE, then the UE can transmit and receive the data packets simultaneously on multiple carriers to meet service requirements. As the available RBs are not sufficient to suffice the service requirements, another available CC of the existing LTE carrier is aggregated at the eNB to fulfil the QoS requirements. In this manner, the proposed LBCAA is configured to aggregate upto five CCs of the existing LTE carriers at the eNB based on cell load to handle the data traffic growth and to meet QoS requirements.

VI. SIMULATION ASSUMPTIONS AND MODELS

The performance of the LTE and proposed LBCAA LTE-Advanced networks are evaluated using QualNet 8.2 network simulator. The simulation parameters considered for the simulation studies are listed in Table II.

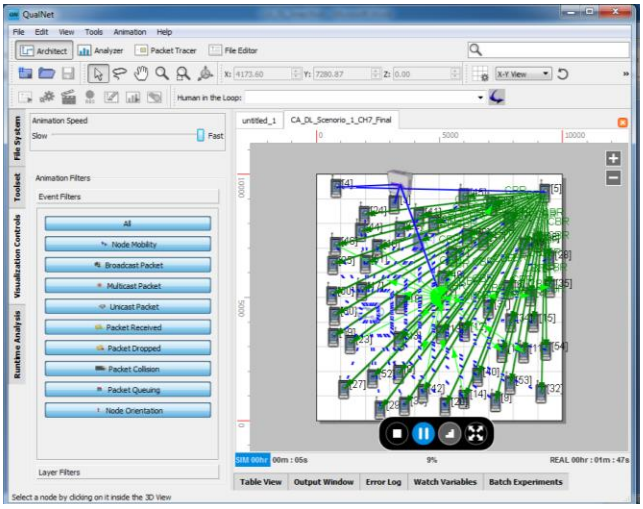

Fig. 6.Snapshot of the scenario designed for simulation studies

The snapshot of the scenario designed for simulation studies using QualNet 8.2 network simulator as shown in Fig. 6. The designed scenario consists of EPC subnet, macro eNB and 50 stationary UEs. The macro eNB is configured with 20MHz channel bandwidth and upto five CCs each with 20MHz are available for CA to increase the transmission bandwidth upto 100MHz. The macro eNB is also configured with 2×2 Open Loop Spatial Multiplexing (OLSM) antenna scheme and is located at the centre of the terrain area of 10Km×10Km. All 50 stationary UEs are placed randomly in the radio range of macro eNB and are connected to macro eNB with a downlink Constant Bit Rate (CBR) data traffic. All UEs supports three frequency bands. Proportional Fairness (PF) scheduling algorithm is used for packet scheduling. Initially, the simulation study is carried out for macro eNB configured with 20MHz channel bandwidth by connecting all 50 stationary UEs to the macro eNB with 100Kbps downlink data rates for a simulation time of 60 seconds. The performance metrics such as total unicast data bytes received, average unicast received throughput, average unicast end-to-end delay, average unicast jitter and total Transport Blocks (TBs) received with errors are measured. The simulation studies are repeated with same simulation setup by changing CBR downlink data rates to 300Kbps, 500Kbps, 1Mbps, 2Mbps, 3Mbps, 4Mbps, 5Mbps and 10Mbps. The above performance evaluation process is repeated for LTE-Advanced network with proposed LBCAA. The proposed LBCAA is configured to aggregate upto five CCs each with 20MHz at the macro eNB to increase the transmission bandwidth 40MHz, 60MHz, 80MHz and 100MHz. The performance of the different bandwidth configured proposed LBCAA LTE-Advanced network is compared with the LTE network.

Table-II: Simulation Parameters

Property		Value
Simulation Time		60 seconds
Downlink-Channel-Frequency		2.32 GHz
Propagation-Model		Statistical
Path loss Model		Two-Ray
Fading Model		Rayleigh
Shadowing Mean (dB)		4
Item Size (bytes)		512
Shadowing Model		Constant
Antenna-Model		Omnidirectional
eNB	PHY- Tx-Power (dBm)	46
	PHY- Num-Tx-Antennas	2
	PHY- Num-Rx-Antennas	2
	Channel-Bandwidth (MHz)	20
	DL Channel Index [0]	1300
	DL Channel Index [1]	900
	DL Channel Index [2]	700
	DL Channel Index [3]	400
	DL Channel Index [4]	200
	Antenna-Height	15m
	Noise Factor	5
UE	PHY- Tx-Power	23dBm
	PHY- Tx-Antennas	1
	PHY- Rx-Antennas	2
	PHY- Supported Frequency Bands	3
	Antenna-Height	1.5m
	Noise Factor	10
	MAC- Scheduler-Type	Simple-Scheduler

VII. SIMULATION RESULTS AND DISCUSSIONS

Fig.7 and Table III shows the total unicast data received performance of the UEs in the LTE and proposed LBCAA LTE-Advanced networks for different data rates. It is observed from Fig.7 and Table III that the total unicast data received by the UEs are almost equal for upto 1Mbps data rates in both LTE and proposed LBCAA LTE-Advanced networks. This is because the data traffic is within its capacity and hence sufficient numbers of RBs are available to forward the data packets. It is also observed from Fig.7 and Table III that the total unicast data received by the UEs increases for increase in data rates and is better with higher transmission bandwidth.

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This is because increase in transmission bandwidth reduces the network congestion and provides sufficient number of RBs to forward the data packets.

This significantly reduces the data packets transmission delay and queuing delay. Further the aggregated CCs allows a UE to transmit and receive data packets simultaneously on multiple CCs within the transmission intervals in turn to increase in total unicast data received performance [20][24][25].

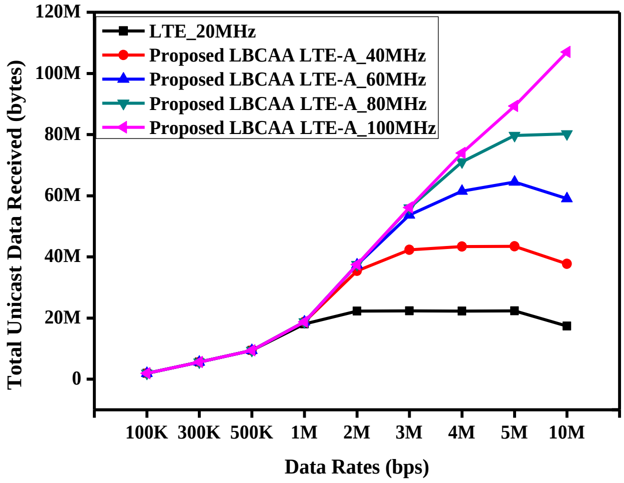

Fig. 7.Total unicast data bytes received by the UEs in the LTE and proposed LBCAA LTE-Advanced networks for different data rates

Table-III: Total unicast data received (MB)

Data Rates (bps)	Transmission Bandwidth (MHz)				
	20	40	60	80	100
100K	1.8944	1.8944	1.8944	1.8944	1.8944
300K	5.632	5.632	5.632	5.632	5.632
500K	9.3952	9.3952	9.3952	9.3952	9.3952
1M	18.0440	18.7648	18.7648	18.7648	18.7648
2M	22.2510	35.4519	37.3980	37.5030	37.5030
3M	22.3273	42.3086	53.7202	56.0161	56.1389
4M	22.2986	43.4007	61.4979	71.0882	73.9620
5M	22.3258	43.4750	64.4670	79.6724	89.3712
10M	17.4024	37.6801	59.0536	80.2027	107

Fig.8 and Table IV shows the average unicast received throughput performance of the UEs in the LTE and proposed LBCAA LTE-Advanced networks for different data rates. It is evident from Fig.8 and Table IV that the average unicast received throughput of UEs is almost equal for data rates upto 1Mbps in both LTE and proposed LBCAA LTE-Advanced networks.

This is because the cell load is within its capacity and hence required numbers of RBs are available for data transmissions. It is also depicted from Fig. 8 and Table IV that the average unicast received throughput is better for proposed LBCAA LTE-Advanced network with higher transmission bandwidth. Since, increase in transmission bandwidth reduces the network congestion and increases the average number of RBs available for data transmissions. Further the aggregated CCs allow a UE to transmit and receive data packets simultaneously on multiple carriers depending on UE capability and downlink scheduler within the transmission intervals in turn to increase in average unicast received throughput[8] [20].

From Fig.8 and Table IV it is also evident that the average unicast received throughput of UEs noticeably deteriorates with higher data rates with all transmission bandwidth. This is because increase in data rates increases the time taken to analyze header information of the data packets. Furthermore the higher data rates services suddenly increase the data traffic, network congestion in turn to increase in data packets transmission delay and queuing delay. This radically reduces the average unicast received throughput even if the sufficient number of RBs available for data transmissions [24] [27].

It is also evident from Fig.8 and Table IV that the average unicast received throughput of UEs in the LBCAA LTE-Advanced network is much better than the LTE network. Since in LTE-Advanced network a UE can transmit and receive data packets on upto 5CCs each with 20MHz, whereas in LTE network a UE can transmit and receive data packets on a single CC with 20MHz bandwidth.

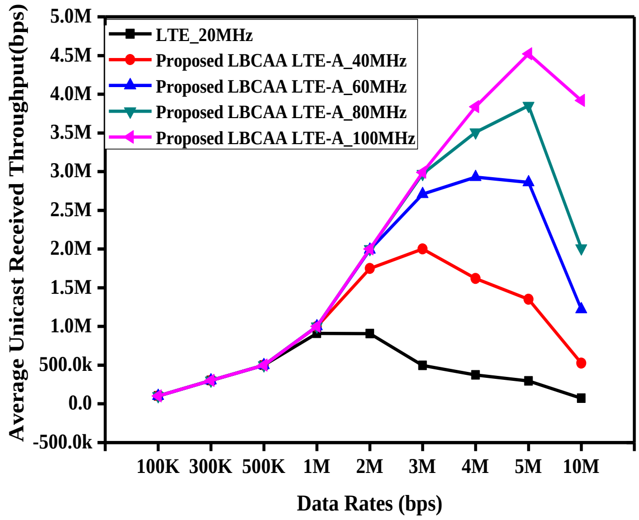

Fig. 8.Average unicast received throughput performance of the UEs in the LTE and proposed LBCAA LTE-Advanced networks for different data rates

Table-IV: Average unicast received throughput (bps)

Data Rates (bps)	Transmission Bandwidth (MHz)				
	20	40	60	80	100
100K	100K	100K	100K	100K	100K
300K	300K	300K	300K	300K	300K
500K	500K	500K	500K	500K	500K
1M	0.911M	0.999M	1M	1M	1M
2M	0.908M	1.75M	1.99M	2M	2M
3M	0.497M	2M	2.71M	2.97M	2.99M
4M	0.375M	1.62M	2.93M	3.51M	3.84M
5M	0.297M	1.35M	2.86M	3.85M	4.52M
10M	0.073M	0.526M	1.22M	2.01M	3.92M

Fig.9 and Table V shows the average unicast end-to-end delay performance of the UEs in the LTE and proposed LBCAA LTE-Advanced networks for different data rates.

It is observed from Fig.9 and Table V that the average end-to-end delay of the UEs is less and is almost equal for upto 1Mbps data rates in the proposed LBCAA LTE-Advanced network.

This is due to less network congestion and the availability of sufficient number of RBs for data transmissions the data packets may not delayed by data packets transmission delay and queuing delay.

However with 20MHz transmission bandwidth due to network congestion and scarcity of RBs the data packets may undergo with transmission delay and queuing delay in turn to increase in average end-to-end delay.

It is also evident from Fig.9 and Table V that as the data rates exceeds 1Mbps the average unicast end-to-end delay of UEs increases rapidly and is more with lower transmission bandwidth network.

This is due to scarcity of RBs and increase in data traffic. Furthermore, increase in data rates increase the time taken to analyze header information of data packets and also the data packets are processed in First-In-First-Out (FIFO) order. Hence the data packets being queued before transmitted so that the delay is quite considerable in higher data rates and is more with lower transmission bandwidth [20] [24] [27].

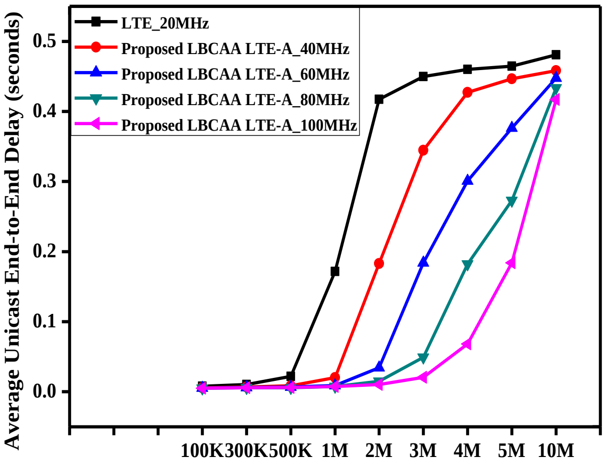

Fig. 9.Average unicast end-to-end delay performance of the UEs in the LTE and proposed LBCAA LTE-Advanced networks for different data rates

Table-V: Average unicast end-to-end delay (ms)

Data Rates (bps)	Transmission Bandwidth (MHz)				
	20	40	60	80	100
100K	7.913	5.918	5.423	5.234	5.221
300K	10.402	6.953	6.022	5.637	5.59
500K	21.969	8.461	6.658	5.902	6.012
1M	171.487	20.263	8.93	7.596	7.581
2M	417.418	182.802	34.302	14.841	10.53
3M	449.764	344.764	184.075	49.252	20.613
4M	459.895	427.138	300.833	182.24	68.39
5M	464.557	446.459	376.353	273.01	184.14
10M	480.692	458.091	447.566	433.42	416.93

Fig.10 and Table VI shows the average unicast jitter performance of the UEs in the LTE and proposed LBCAA LTE-Advanced networks for different data rates. It is observed from Fig.10 and Table VI that the average unicast jitter of UEs decreases for increase in data rates and is less with higher transmission bandwidth. Because increase in data rates increases the RBs utility and the higher transmission bandwidth provides sufficient number of RBs for data transmissions by reducing the network congestion in turn to reduction in the data packets transmission delay and queuing delay. This considerably reduces the variations in the delay of received packets. It is also evident from Fig.10 and Table VI that increase in data rates with 20MHz transmission bandwidth increases the jitter. This is due to network congestion and scarcity of RBs the data packets delayed with transmission delay and queuing delay in turn to increase in the variations in the delay of received data packets [20][27][30].

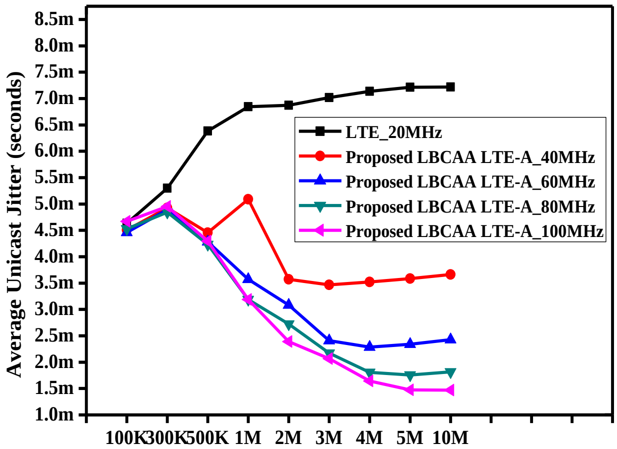

Fig. 10. Average unicast jitter performance of the UEs in the LTE and proposed LBCAA LTE-Advanced networks for different data rates

Table-VI: Average unicast jitter (ms)

Data Rates (bps)	Transmission Bandwidth (MHz)				
	20	40	60	80	100
100K	4.633	4.504	4.461	4.53	4.67
300K	5.301	4.926	4.893	4.843	4.954
500K	6.383	4.456	4.283	4.231	4.294
1M	6.844	5.09	3.569	3.189	3.189
2M	6.87	3.571	3.083	2.723	2.39
3M	7.019	3.465	2.41	2.173	2.065
4M	7.135	3.519	2.284	1.806	1.644
5M	7.213	3.586	2.34	1.755	1.474
10M	7.219	3.664	2.428	1.818	1.47

Fig.11 and Table VII shows the Transport Blocks (TBs) received with errors for the UEs in the LTE and proposed LBCAA LTE-Advanced networks for different data rates. It is observed from Fig.11 and Table VII that the TBs received with errors is noticeably less with higher transmission bandwidth. Because higher transmission bandwidth provides sufficient number of RBs for data transmissions with reduced network congestion and hence less number of data packets received with errors.

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This prominently reduces the TBs received with errors. It is also evident from Fig.11and Table VII that the TBs received with errors increases for increase in data rates and is more with lower transmission bandwidth due to increase in network congestion and scarcity of RBs [20] [27] [31].

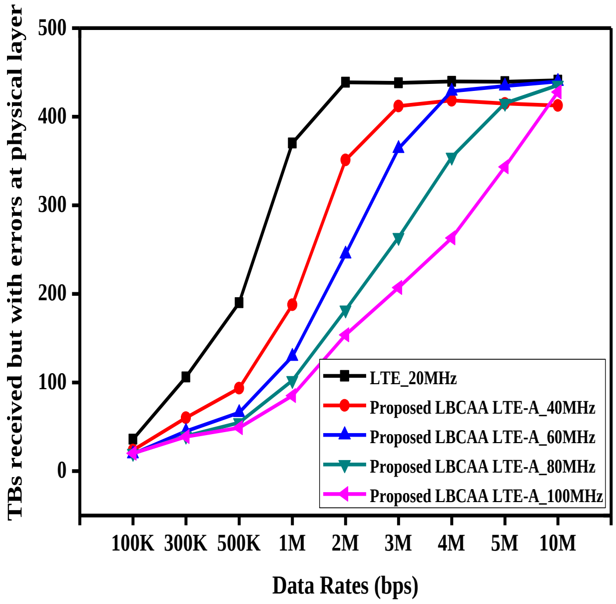

Fig. 11. UEs Transport Blocks (TBs) received with errors in the LTE and proposed LBCAA LTE-Advanced networks for different data rates

Table-VII: Transport Blocks (TBs) received but with errors at Physical Payer

Data Rates (bps)	Transmission Bandwidth (MHz)				
	20	40	60	80	100
100K	36.0784	23.7255	19.5686	20.1373	20.294
300K	106.176	60.3922	45.1961	39.5686	38.843
500K	190.059	93.6863	66.2941	54.8824	48.902
1M	370.176	187.804	129.647	102.373	85.274
2M	438.843	351.02	245.078	181.961	153.90
3M	438.333	411.961	364	263.843	207.33
4M	439.686	418.549	428.725	354.275	263.10
5M	439.608	415.02	434.725	415.275	343.37
10M	441.098	412.647	439.98	435.569	427.80

VIII. CONCLUSION

This paper has inspected the data traffic handling of LTE-Advanced network with CA scheme. The proposed LBCAA is focused on a selection and aggregation of available CC of the existing LTE carriers at the eNB to increase the transmission bandwidth of LTE-Advanced network to handle the data traffic growth. The proposed LBCAA is designed and its performance is studied using Qualnet 8.2 network simulator. The proposed LBCAA aggregates the CCs of the existing LTE carriers when the cell load exceeds its capacity. Then, it efficiently utilizes the allocatable available RBs of LTE and the aggregated CCs for data transmissions to satisfy the QoS requirements of data intensive services and to handle the data traffic growth efficiently. The obtained simulations results illustrated that the proposed LBCAA for LTE-Advanced network enhance the user throughput significantly with reduced latency as compared to LTE network.

REFERENCES

1. Hrishikesh Venkataraman, Ramona Trestian, "5G Radio Access Networks: Centralized RAN, Cloud-RAN, and Virtualization of Small Cells", © 2017 by Taylor & Francis Group, LLC.
2. V. Srinivasa Rao, "Protocol Signaling Procedures in LTE", White Paper, radisys.
3. Dennis Mahoney, David Schnaufer, "Carrier Aggregation: Implications for Mobile-Device RF Front-Ends", Feb 19, 2016.
4. Mikio Iwamura, Kamran Etemad, Mo-Han Fong, Ravi Nory, Robert Love, "Carrier Aggregation Framework in 3GPP LTE-Advanced", IEEE Communications Magazine, August 2010.
5. Ayman Elnashar, Mohamed A. El-saidny, "Practical Guide to LTE-A, VoLTE and IoT: Paving the way towards 5G", John Wiley and Sons, 2018.
6. Qinlong Wang, Qixun Zhang, Yuhang Sun, Zhiqing Wei, Zhiyong Feng, "A QoS-Guaranteed Radio Resource Scheduling in Multi-User Multi-Service LTE-Advanced Systems with Carrier Aggregation", 2016 2nd IEEE International Conference on Computer and Communications.
7. Kukushkin, Alexander, "Introduction to Mobile Network Engineering: GSM, 3G-WCDMA, LTE and Teh road to 5G", John Wiley & Sons, 2018.
8. Xiaojia Lu, Markku Juntti Mikko Valkama Joseph R. Cavallaro Shuvra S. Bhattacharyya, "Subcarrier Allocation and Power Control with LTE-Advanced Carrier Aggregation", ©2013 IEEE, GlobalSIP 2013.
9. https://www.3gpp.org/technologies/keywords-acronyms/101-carrier-aggregation-explained.
10. Rapeepat Ratasuk, Amitava Ghosh, "Carrier Aggregation and Dual Connectivity", Nokia Bell Labs, ISART 2017.
11. Chunyan Li, Ben Wang, Weidong Wang, Yinghai Zhang, Xinyue Chang, "Component Carrier Selection for LTE-ADVANCEDSystems in Diverse Coverage Carrier Aggregation Scenario", 2012 IEEE 23rd International Symposium on Personal, Indoor and Mobile Radio Communications - (PIMRC).
12. Raja Karmakar, Samiran Chattopadhyay, Sandip Chakraborty, "A Learning-based Dynamic Clustering for Coordinated Multi-Point (CoMP) Operation with Carrier Aggregation in LTE-Advanced", 2018 10th International Conference on Communication Systems & Networks (COMSNETS).
13. Lea Fadlan, Tutun Juhana, "Performance Analysis of Inter-band and Intra-band CA on Planning and Dimensioning LTE-Advanced in Bandung City", The 3rd International Conference on Wireless and Telematics 2017.
14. Haeyoung Lee, Seiamak Vahid, Klaus Moessner, "A Survey of Radio Resource Management for Spectrum Aggregation in LTE-Advanced", IEEE Communications Surveys & Tutorials.
15. Soheil Rostami, Kamran Arshad, Predrag Rapajic, "Optimum Radio Resource Management in Carrier Aggregation based LTE-Advanced Systems".
16. Zukang Shen, Aris Papasakellariou, Juan Montojo, Dirk Gerstenberger, Fangli Xu, "Overview of 3GPP LTE-Advanced Carrier Aggregation for 4G Wireless Communications", IEEE Communications Magazine, February 2012.
17. Yuanye Wang, Klaus I. Pedersen, Troels B. Sørensen, Preben E. Mogensen, "Carrier Load Balancing and Packet Scheduling for Multi-Carrier Systems", IEEE Transactions on Wireless Communications, Vol. 9, No. 5, May 2010.
18. Haya Shajaiah, Ahmed Abdelhadi, T. Charles Clancy, "Towards an Application-Aware Resource Scheduling With Carrier Aggregation in Cellular Systems", IEEE Communications Letters, Vol. 20, No. 1, January 2016.
19. Irfan Baig, Saptarshi Chaudhuri, Debabrata Das, "A Dynamic Scheme for User Load Balancing in a Multi-Carrier LTE-Advanced Network", ©2016 IEEE.
20. Erik Dahlman, Stefan Parkvall, Johan Skold, "4G, LTE-Advanced Pro and The Road to 5G", Third Edition, Copyright © 2016, Published by Elsevier Ltd.
21. Anritsu Discover what's Possible, "Understanding LTE-Advanced Carrier Aggregation".
22. Afif Osseiran, Jose F. Monserrat, Werner Mohr, "Mobile and Wireless Communications for IMT-Advanced and Beyond", © 2011, John Wiley & Sons Ltd.
23. Harri Holma, Antti Toskala, Jussi Reunanen, "LTE Small Cell Optimization 3GPP Evolution to Release 13", © 2016 John Wiley & Sons Ltd.

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24. 3GPP TR 36.814,"Further advancements for E-UTRA physical layer aspects", V1.5.1 (2009-12).
25. Haya Shajaiah, Ahmed Abdelhadi, Charles Clancy, "Resource Allocation with Carrier Aggregation in Cellular Networks", © Springer International Publishing AG 2018.
26. Mohana H K, Mohankumar N M, Swetha, Devaraju J T, "Effect of Bandwidth Scalability on System Performance in the Downlink LTE Systems", International Journal of Advanced Research in Computer Science, Volume 5, No. 7, September-October 2014.
27. Christopher Cox, "An Introduction to LTE: LTE, LTE-Advanced, SAE, VoLTE and 4G Mobile Communications", Second Edition, © 2014 John Wiley & Sons, Ltd.
28. SeungJune Yi, SungDuck Chun, YoungDae Lee, SungJun Park, SungHoon Jung, "Radio Protocols for LTE and LTE-Advanced", First Edition, © 2012 John Wiley & Sons Singapore Pvt. Ltd.
29. Guangxiang Yuan, Xiang Zhang, Wenbo Wang, Yang Yang, "Carrier Aggregation for LTE-Advanced Mobile Communication Systems", IEEE Communications Magazine, February 2010.
30. Mohana H K, Mohankumar N M, Suhas K R, Devaraju J T, "Performance Evaluation of Mobility Effects on Various Transmission Modes in the LTE Network", IJSER, Vol.6 (6), June-2015.
31. Mohana H.K., Nethra H.S. and Devaraju J.T., "HARQ Scheme for different MCS users over LTE and LTE-Advanced Networks", Int. J. Sc. Res. in Network Security and Communication, Vol.10 (2), April 2022.

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